US009681069B2

(12) **United States Patent**
**El-Ghoroury et al.**

(10) **Patent No.: US 9,681,069 B2**
(45) **Date of Patent: Jun. 13, 2017**

(54) **SPATIO-TEMPORAL LIGHT FIELD CAMERAS**

(71) Applicant: **Ostendo Technologies, Inc.**, Carlsbad, CA (US)

(72) Inventors: **Hussein S. El-Ghoroury**, Carlsbad, CA (US); **Zahir Y. Alpaslan**, San Marcos, CA (US); **Jingbo Cai**, Carlsbad, CA (US); **Marty Maiers**, Fallbrook, CA (US); **Philip Warner**, San Marcos, CA (US); **Dale A. McNeill**, Encinitas, CA (US)

(73) Assignee: **Ostendo Technologies, Inc.**, Carlsbad, CA (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1 day.

(21) Appl. No.: **14/872,862**

(22) Filed: **Oct. 1, 2015**

(65) **Prior Publication Data**

US 2016/0191823 A1 Jun. 30, 2016

**Related U.S. Application Data**

(62) Division of application No. 13/659,776, filed on Oct. 24, 2012, now Pat. No. 9,179,126.
(Continued)

(51) **Int. Cl.**
***H04N 5/349*** (2011.01)
***H04N 5/225*** (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***H04N 5/349*** (2013.01); ***G02B 3/0012*** (2013.01); ***G02B 13/0085*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC .... H04N 5/225; H04N 5/2253; H04N 5/2254; H04N 5/2257; H04N 5/349; H04N 5/232;
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,059,008 A 10/1991 Flood et al.
5,691,836 A 11/1997 Clark
(Continued)

FOREIGN PATENT DOCUMENTS

CN 102007771 4/2011
EP 1956410 8/2008
(Continued)

OTHER PUBLICATIONS

"Office Action Dated Aug. 2, 2016; U.S. Appl. No. 14/872,929", (Aug. 2, 2016).
(Continued)

*Primary Examiner* — Abdelaaziz Tissire
(74) *Attorney, Agent, or Firm* — Blakely Sokoloff Taylor & Zafman LLP

(57) **ABSTRACT**

Spatio-temporal light field cameras that can be used to capture the light field within its spatio temporally extended angular extent. Such cameras can be used to record 3D images, 2D images that can be computationally focused, or wide angle panoramic 2D images with relatively high spatial and directional resolutions. The light field cameras can be also be used as 2D/3D switchable cameras with extended angular extent. The spatio-temporal aspects of the novel light field cameras allow them to capture and digitally record the intensity and color from multiple directional views within a wide angle. The inherent volumetric compactness of the light field cameras make it possible to embed in small mobile devices to capture either 3D images or computationally focusable 2D images. The inherent versatility of these
(Continued)